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**BOTTOM TRAWL CATCHES OF JUVENILE OPAKAPAKA, *PRISTIPOMOIDES*
FILAMENTOSUS (F. LUTJANIDAE), AND ASSOCIATED FISHES, TOWNSEND
CROMWELL CRUISE TC-90-10, 1990**

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ABSTRACT

Eighty bottom trawls were conducted from the NOAA ship *Townsend Cromwell* (cruise TC-90-10, 28 November-13 December 1990) at 11 windward and leeward regions of Oahu, Molokai, Lanai, and Maui to characterize depth-distribution patterns of opakapaka, *Pristipomoides filamentosus*, and associated fishes. The trawls produced 89 taxa of benthic and epibenthic fishes. The most commonly trawled benthic species was a lizardfish, *Trachinocephalus myops*. The highest mean catch per unit effort (CPUE; number per trawl) was recorded from catches at Kaneohe Bay (224 benthic fish/trawl). Juvenile opakapaka occurred in only 12 trawls, with a total of 125 individuals collected; 108 of these were collected off Kaneohe Bay. Length frequencies of opakapaka were bimodally distributed. The precision of the mean CPUE data from the trawls was insufficient to detect 50% changes in the abundance of either opakapaka or three other major species.

INTRODUCTION

Exploratory fishing was initiated in 1988 to identify the habitat of juvenile eteline snappers (Lutjanidae) in Hawaii (Parrish 1989). The results of that study and evidence from Struhsaker (1973) suggest that juvenile pink snapper or opakapaka, *Pristipomoides filamentosus*, inhabit relatively flat, featureless bottoms at depths of 61-130 m, with few specimens caught at greater depths. Data on the regional variation in depth distributions and on the locations of habitat for juvenile opakapaka are lacking. These data are necessary to fully understand the extent and importance of opakapaka nursery habitat throughout the main Hawaiian islands (MHI).

Our report primarily summarizes the fish catch data collected during a bottom trawl survey conducted from the NOAA ship *Townsend Cromwell* (cruise TC-90-10) and characterizes the benthic and epibenthic fish fauna associated with juvenile opakapaka from these data. Secondly, our report describes the depth distribution patterns of juvenile opakapaka throughout the MHI and evaluates the precision of data on catch per unit effort (CPUE; number caught per trawl) for estimating the abundance of opakapaka and major associated fishes.

MATERIALS AND METHODS

Sampling

Bottom trawls were conducted from the NOAA ship *Townsend Cromwell* (TC-90-10, 28 November-13 December 1990) using two identical, single-warp, 12.2-m semiballoon shrimp trawl nets with wing and other body dimensions proportional to a 22.6-m balloon trawl net (Fig. 1). The bottom trawls used 15-m headropes with six 15-cm cork floats and four additional 25-cm metal floats, and 12-m footropes with fifteen 15-cm plastic roller floats. A tickler chain and a 0.675-cm cod-end liner were used throughout the survey. The bottom trawls also used 1.4 by 2.0 m otter boards to keep the mouth of the net open during the trawls. Trawling depth was recorded by time-depth recorders (TDRs) and by a chromascope depth-sounder aboard the *Townsend Cromwell*. The TDRs were attached to the headropes of the trawls.

Eighty bottom trawls (52 night trawls and 18 trawls for the day-night series) were completed at 11 windward and leeward regions of the MHI (Fig. 2; Table 1), of which 72 (90%) were quantitative tows (QTs). A trawl was defined as non-quantitative (NQ) if the gear was lost or broken or if the tow deviated from the desired bearing or depth or was aborted; all other trawls were quantitative. Regions were chosen based on historical evidence for juvenile opakapaka (Struhsaker 1973). At each

region, one to six trawls were made at one to three bottom depths (shallow: 61 m; mid-depth: 76 m; deep: 91 m; Appendix A). Tow speeds ranged from 1.32 m per second (mps) to 2.63 mps; the mean speed of QTs was 1.94 mps. Mean duration of QTs was 22 minutes \pm 5.6 SD (range, 12-33 minutes). Tow track lengths were less variable than tow durations. Changes in sea state and in the condition of the otter boards required adjustments in tow speeds or durations to maintain approximately constant tow distances. Tow distances ranged from 1.74 to 3.12 km. The mean distance of QTs was 2.51 km \pm 0.26 SD (Appendix B). A standard unit of effort, equal to a constant tow distance of 2.51 km, was assumed in all CPUE calculations.

Several series of day-night trawls were conducted off Oahu (Haleiwa and Kaneohe Bay) and off Molokai (southeast (SE) Penguin Bank; Fig. 2) for diel comparisons of catch-at-depth. However, many trawls were NQ, and complete series of six day and six night trawls were not completed at the three regions because of rough seas and gear loss. Three day and six night QTs were completed at SE Penguin Bank, and five day and two night QTs were completed at Haleiwa. No QTs were completed at Kaneohe Bay for the day-night comparisons.

Types of Data

The total number and cumulative biomass (kilograms wet weight) of fish caught were recorded for each trawl. Invertebrates were counted, weighed, and preserved in formalin for later identification; results will be reported elsewhere. Opakapaka were measured to the nearest 0.1 cm fork length (FL) and frozen whole for later age-at-length determination. Fish were classified to the lowest identifiable taxa. Questionable species were verified through references (Appendix C). The number (and biomass if aggregate weight of individuals of a species was >0.01 kg) of individuals was also recorded by taxon and by region.

Statistical Power Analysis

It was assumed that future comparisons of CPUE data from trawls with prior series of data similar to ours would use a Student's *t*-test or other similar statistical test. Therefore, we used our trawl data to estimate the power of *t*-test comparisons of means for opakapaka at Kaneohe Bay, and for each of three other species for all regions combined, in order to determine whether a 50% change in CPUE could be detected. This criterion of 50% has precedence in environmental monitoring studies (e.g., Skalski and McKenzie 1982). All depths were pooled within each region. Data were transformed to common (base 10) logarithms, then the effect size (ES) was calculated:

$$ES = 0.301/SD,$$

where $0.301 = |\pm 50\% \text{ difference in } x|$ for log-transformed catch data. Tables 2.3.5 and 2.4.1 in Cohen (1988) were used to determine the requisite number of trawls at $\beta = 0.20$, power $(1 - \beta) = 0.8$, and $\alpha_2 = 0.05$.

RESULTS AND DISCUSSION

The trawls yielded 89 taxa of benthic and epibenthic fishes (Appendix D). Individual fish totaled 4,411 in the 72 QTs; 229 individuals were also caught in the 8 NQs. Thirty-five percent of the cumulative catch was caught in the 5 trawls made off Kaneohe Bay, and over 78% in 28 trawls at 4 different regions off Oahu. The CPUE decreased noticeably if data from the day trawls were included. Prior studies (see review by DeMartini and Allen 1984) have indicated that diversity (species richness) is generally greater and variations in CPUE are less in night than in day trawls. Henceforth, the data for diel-comparison trawls are omitted from our CPUE comparisons.

The most numerous fish caught (1,401 individuals in 40 of 72 QTs) was a myctophid, *Benthosema fibulatum*, comprising 32% of the total catch (Appendix E). However, it was excluded from our abundance and biomass comparisons, because observations of Reid et al. (1991) suggest that it is a land-associated mesopelagic species rather than a benthic species. Other species known to be meso- or epipelagic also were deleted (one *Astronesthes* sp.; six opelu, *Decapterus macarellus*). The epibenthic pufferfish *Lagocephalus hypselogeneion* ranked first in frequency caught for all regions pooled, because of the large numbers caught at Kaneohe Bay and Laie (Fig. 3C-D). *Lagocephalus hypselogeneion* also ranked first in total weight (73.89 kg) if elasmobranchs were excluded (Appendix F). Otherwise, a stingray, *Dasyatis* sp., ranked first in biomass (three specimens weighing an estimated 95 kg).

The highest CPUEs were recorded off Kaneohe Bay and Laie, with means of 224 fish/trawl and 149 fish/trawl, respectively (Table 2). Catches were more variable at Laie than at Kaneohe Bay. Lahilahi Point, leeward Oahu, had the lowest CPUE of all the regions, with a mean of 3 fish/trawl (Table 2). The mean CPUE data of top-ranked species by number of individuals are illustrated for 8 of the 11 regions in Figure 3. Trawl CPUE data for the other three regions were negligible. A synodontid, *Trachinocephalus myops* ranked first in abundance at 6 of the 11 regions and second at 2 of the remaining 5 regions. Of the other top-ranked species, only *Lagocephalus hypselogeneion* (top-ranked in 6 of 11 regions) and the bothid *Engyprosopon xenandrus* (top-ranked in 8 of 11 regions) commonly occurred.

When the regions were pooled by depth, *Trachinocephalus myops* was the most abundant species in the deep trawls (Table 3). Moreover, it was commonly encountered (15 trawls at 8 of 10 deep regions and 18 trawls at 8 of 10 mid-depth regions). *Lagocephalus hypselogeneion* was most abundant in mid-depth trawls and was also commonly encountered (11 trawls at 7 of 10 deep regions and 9 trawls at 5 of 10 mid-depth regions). No species was both abundant and frequently encountered at the shallow depths. The sandlance *Bleekeria gilli* was the most abundant fish in the shallow trawls, but occurred in only two of six trawls (at one of three regions, Laie). Other species were too variable between regions and trawls for us to speculate on patterns of abundance. An apparent difference in CPUE, with all species combined, between mid-depth and deep trawls (cf. Table 2) was not supported by statistical comparison (Wilcoxon signed-ranks test; $T = 9$, $N = 8$ pairs, $P > 0.05$). Species richness appeared greater in the deep (54 species) and mid-depth trawls (60 species) than in the shallow trawls (15 species), but this may reflect the variability in the number of trawls at each depth.

Juvenile Opakapaka

Juvenile opakapaka occurred in only 12 (17%) of the 72 QTs at 5 of the 11 regions fished. A total of 125 opakapaka were collected; 108 (86%) of these were caught in the 5 QTs made off Kaneohe Bay. The second largest catch of juvenile opakapaka occurred off Laie (eight fish in one of six trawls). All of the opakapaka were juveniles. The distribution patterns of opakapaka in the windward and leeward regions were not compared because of insufficient data. The length-frequency distribution of the opakapaka was markedly bimodal (Fig. 4). This is thought to represent two age classes of fish: Age-1+ juveniles from a 1989 spawning, and 6-month-old (age-0+) juveniles from a mid-1990 spawning (R. Moffitt, Honolulu Laboratory, unpubl. data; R. Humphreys and K. Landgraf, Honolulu Laboratory, unpubl. data). Juvenile opakapaka smaller than 8-cm FL were conspicuously absent from our trawls, as in prior hook-and-line collections made at Kaneohe Bay (R. Moffitt, unpubl. data).

Juvenile opakapaka were caught most frequently in trawls ranging from 64-80.1 m deep (Fig. 5, regions pooled). However, their depths-at-capture cannot be meaningfully compared, as nearly all of the catches were made at one region. Age-1+ opakapaka occurred only in mid-depth trawls, and some age-0+ opakapaka were caught in deep trawls but were also frequently encountered in mid-depth trawls.

Power Tests

One might question whether a bottom trawl is an adequate sampler for estimating distribution and abundance of juvenile

opakapaka in the MHI. Our power analysis estimated that nearly 100 trawls, an unacceptably large number, would be necessary to detect a 50% change in juvenile opakapaka catches at $\alpha_2 = 0.05$ and a power = 0.8. For nonstatistical reasons, an upper limit of an "acceptable" number of trawls was set at 20. This upper limit was defined partly by the feasible effort and duration of trawling aboard the *Townsend Cromwell* (six to seven trawls per day for 3 days) and partly by a desire to limit habitat damage resulting from trawling activities. Additional power tests to detect a 50% change in catch were calculated for each of the three most frequently encountered species (*Trachinocephalus myops*, *Lagocephalus hypselogeneion*, and *Engyprosopon xenandrus*). Sufficient power (≥ 0.8) for ≤ 20 trawls was indicated for only 3 of the 36 possible species-region combinations (species by region with depths pooled). Data for *E. xenandrus* had no power of resolution, *T. myops* had two instances of adequate power ($N = 9$, 10 trawls), and *L. hypselogeneion* had one instance ($N = 9$). In general, a 50% change in the mean CPUE would likely go undetected for any of the major species sampled by bottom trawls.

In conclusion, bottom trawls do not promise to be an efficient sampling method for the detection of changes in the abundance of small benthic fishes at 61-91 m depths off the MHI. We are presently exploring alternative methods to characterize the depth-distribution range and habitat type of juvenile opakapaka.

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CITATIONS

- Cohen, J.
1988. Statistical power analysis for the behavioral sciences. Second edition. Lawrence Erlbaum Associates, Hillsdale, N.J., 567 p.
- DeMartini, E. E. and L. G. Allen.
1984. Diel variation in catch parameters for fishes sampled by a 7.6-m otter trawl in southern California coastal waters. CalCOFI Rep. Vol. XXV, p. 119-134.
- Parrish, F. A.
1989. Identification of habitat of juvenile snappers in Hawaii. Fish. Bull., U.S. 87:1001-1005.

- Reid, S. B., J. Hirota, R. E. Young, and L. E. Hallacher.
1991. Mesopelagic-boundary community in Hawaii:
micronekton at the interface between neritic and
oceanic ecosystems. Mar. Biol. 109:427-440.
- Skalski, J. R. and D. H. McKenzie.
1982. A design for aquatic monitoring programs. J.
Environ. Manage. 14:237-251.
- Struhsaker, P.
1973. A contribution to the systematics and ecology of
Hawaiian bathyal fishes. Ph.D. dissertation. Univ.
Hawaii, Honolulu, 482 p.
- U.S. Fish and Wildlife Service
1951. Gulf of Mexico shrimp trawl designs. United States
Department of Interior, U. S. Fish and Wildlife
Service, Fishery Leaflet 394. 16 p.

Table 1.--Boundaries of the 11 regions trawled during the
Townsend Cromwell cruise TC-90-10.

Region ^a	Trawl area bounded by	
	Latitude (N)	Longitude (W)
Haleiwa	21°36.4'-21°42.0'	158°04.0'-158°11.7'
Kaneohe Bay	21°30.8'-21°33.9'	157°47.6'-157°49.1'
Laie	21°38.8'-21°41.9'	157°53.0'-157°55.0'
NW Molokai	21°11.7'-21°12.5'	157°03.0'-157°05.7'
NE Penguin Bank	21°06.7'-21°09.7'	157°19.8'-157°24.0'
SE Penguin Bank	21°02.9'-21°04.3'	157°11.6'-157°18.1'
South Molokai	21°00.1'-21°02.8'	156°56.0'-157°01.1'
Kahului, Maui	20°57.1'-20°59.0'	156°24.7'-156°28.6'
Auau Channel	20°44.1'-20°49.4'	156°42.2'-156°47.3'
South Lanai	20°42.8'-20°43.3'	156°53.3'-156°55.0'
Lahilahi Pt.	21°26.9'-21°30.1'	158°13.3'-158°14.6'

^aListed in order of cruise track.

Table 2.--Total catch and catch per unit effort, by depth and region, from Townsend Cromwell cruise 90-10 in the main Hawaiian Islands, 1990. Data are from nighttime quantitative trawls only; catches from several series of daytime and nighttime trawls are excluded. Weight (Wt) is expressed as 0.01 kg.

Region	Depth zone	No. trawls	Total catch		Mean·trawl ⁻¹	
			No.	Wt.	No.	Wt.
Auau Channel	Mid-depth	3	51	2.13	17	0.71
	Combined	3	51	2.13	17	0.71
Haleiwa, Oahu	Mid-depth	3	50	1.51	17	0.50
	Deep	3	200	5.13	67	1.71
	Combined	6	250	6.64	42	1.11
Kahului, Maui	Mid-depth	3	74	2.04	25	0.68
	Deep	3	59	0.94	20	0.31
	Combined	6	133	2.98	22	0.50
Kaneohe Bay, Oahu	Mid-depth	3	748	43.92	249	14.64
	Deep	2	373	14.43	187	7.21
	Combined	5	1121	58.35	224	11.67
Lahilahi Point, Oahu	Mid-depth	3	10	0.05	3	0.02
	Deep	1	3	0.01	3	0.01
	Combined	4	13	0.06	3	0.02
Laie, Oahu	Shallow	2	148	9.94	74	4.97
	Mid-depth	2	597	42.21	299	21.10
	Deep	2	146	9.13	73	4.57
	Combined	6	891	61.28	149	10.21
NE Penguin Bank	Shallow	2	20	0.03	10	0.02
	Mid-depth	2	26	0.65	13	0.33
	Deep	1	9	0.14	9	0.14
	Combined	5	55	0.82	11	0.16
NW Molokai	Shallow	2	23	0.95	12	0.47
	Mid-depth	2	50	2.77	25	1.38
	Deep	2	47	1.44	24	0.72
	Combined	6	120	5.16	20	0.86
SE Penguin Bank	Mid-depth	4	24	1.55	6	0.39
	Deep	2	18	0.94	9	0.47
	Combined	6	42	2.49	7	0.42
South Lanai	Deep	3	52	1.98	17	0.66
	Combined	3	52	1.98	17	0.66

Table 2.--Continued.

Region	Depth zone	No. trawls	Total catch		Mean•trawl ⁻¹	
			No.	Wt.	No.	Wt.
South Molokai	Mid-depth	3	62	0.57	21	0.19
	Deep	3	57	1.65	19	0.55
	Combined	6	119	2.22	20	0.37
All regions pooled	Shallow	6	191	10.92	32	1.82
	Mid-depth	28	1692	97.40	60	3.48
	Deep	22	964	35.79	44	1.63
	Combined	56	2847	144.11	51	2.57

Table 3.--Absolute and ranked trawl catches, by depth, for each species present in night quantitative trawls (56 trawls) during the Townsend Cromwell cruise TC-90-10. Species listed according to their total rank in Appendix E. *Benthosema fibulatum*, *Decapterus macarellus*, *Astronesthes* sp. are excluded. Deep = 91 m, mid-depth = 76 m, shallow = 61 m; R = rank, N = number of individuals captured.

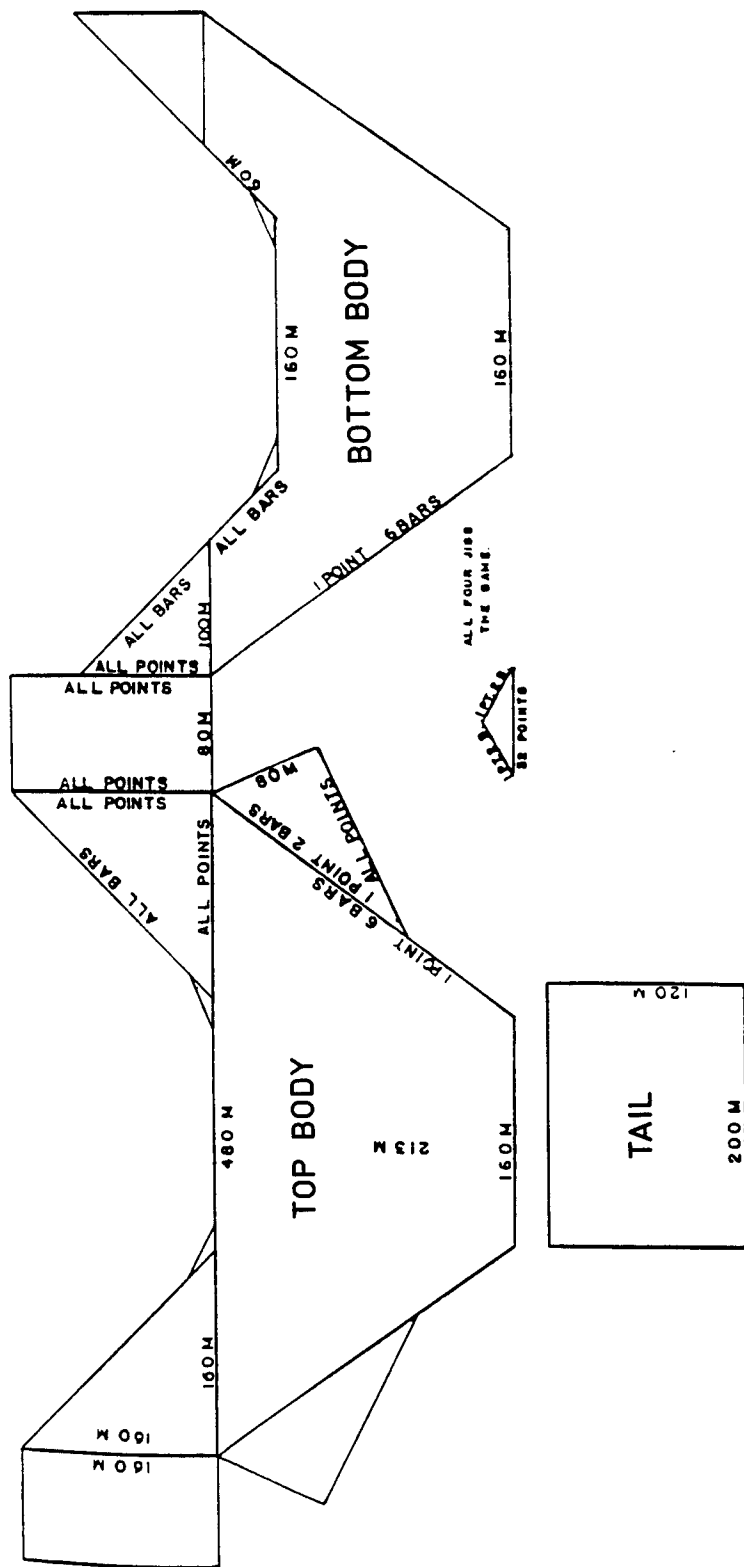
Species	Depth zone					
	Deep			Mid		
	N	R		N	R	
						Shallow
<i>Lagocephalus hypselogeneion</i>	233	2.0		555	1.0	57
<i>Trachinocephalus myops</i>	256	1.0		368	2.0	45
<i>Engyprosope xenandrus</i>	137	3.0		76	6.0	1
<i>Lutjanus kasmira</i>	6	19.0		147	3.0	0
<i>Pristipomoides filamentosus</i>	10	12.5		113	4.0	0
<i>Synagrops argyrea</i>	94	4.0		23	9.0	0
<i>Heniochus dipreutes</i>	6	19.0		99	5.0	1
<i>Ariosoma bowersi</i>	19	6.0		39	7.5	1
<i>Bleekeria gilli</i>	0	-		0	-	64
<i>Dactyloptena orientalis</i>	14	7.0		39	7.5	0
<i>Parupeneus chrysonemus</i>	23	5.0		22	10.5	0
<i>Bothus thompsoni</i>	5	22.5		22	10.5	7
<i>Synodus falcatus</i>	9	14.5		10	15.0	0
<i>Lactoria</i> spp.	6	19.0		17	12.0	2
<i>Gnatholepis anjerensis</i>	13	8.0		8	20.0	0
<i>Priacanthus alalaua</i>	5	22.5		15	13.0	0
<i>Iracundus signifer</i>	4	26.0		3	30.0	0
<i>Canthigaster rivulatus</i>	10	17.0		7	21.0	1
<i>Bothidae</i> (unidentified sp.)	9	14.5		9	17.5	0
<i>Bothus pantherinus</i>	1	45.0		13	14.0	1
<i>Chromis leucura</i>	12	9.5		5	23.5	0
<i>Callionymus decoratus</i>	4	26.0		9	17.5	0
<i>Parapercis schauinsland</i>	4	26.0		3	30.0	4
<i>Mulloidides auriflamma</i>	1	45.0		6	22.0	0
<i>Fistularia petimba</i>	11	11.0		3	30.0	0
<i>Ophidion muraenolepis</i>	12	9.5		0	-	0

Table 3.--Continued.

Species	Depth zone					
	Deep			Mid		
	N	R	N	R	N	R
<i>Parupeneus pleurostigma</i>	1	45.0	9	17.5	0	-
<i>Synodontidae</i> (unidentified sp.)	8	16.0	5	23.5	0	-
<i>Canthigaster epilampra</i>	7	17.0	3	30.0	0	-
<i>Scorpaena colorata</i>	3	30.0	3	30.0	3	6.0
<i>Mulloides flavolineatus</i>	0	-	9	17.5	1	12.0
<i>Chaetodon miliaris</i>	5	22.5	4	25.0	0	-
<i>Saurenhelys</i> sp.	2	34.5	2	39.0	0	-
<i>Chromis verater</i>	5	22.5	0	-	0	-
<i>Haliutaea retifera</i>	3	30.0	2	39.0	0	-
<i>Myripristis chryseres</i>	0	-	2	39.0	0	-
<i>Apogon maculiferus</i>	2	34.5	2	39.0	0	-
<i>Antennarius striatus</i>	1	45.0	3	30.0	0	-
<i>Canthigaster coronatus</i>	1	45.0	2	39.0	0	-
<i>Apogonidae</i> (unidentified sp.)	0	-	3	30.0	0	-
<i>Carapis homei</i>	0	-	2	39.0	0	-
<i>Dasyatis</i> sp.	3	30.0	0	-	0	-
<i>Nomeidae</i> (unidentified sp.)	3	30.0	0	-	0	-
<i>Eurypegasus papilio</i>	2	34.5	1	52.0	0	-
<i>Scorpaenopsis altirostris</i>	0	-	3	30.0	0	-
<i>Scorpaenopsis brevifrons</i>	0	-	3	30.0	0	-
<i>Oxycirrhites typus</i>	3	30.0	0	-	0	-
<i>Anthias thompsoni</i>	1	45.0	1	52.0	0	-
<i>Upeneus arge</i>	0	-	2	39.0	0	-
<i>Apogon snyderi</i>	0	-	2	39.0	0	-
<i>Centropyge potteri</i>	2	34.5	0	-	0	-
<i>Hippocampus kuda</i>	1	45.0	1	52.0	0	-
<i>Sphyraena japonicus</i>	0	-	0	-	0	-
<i>Synodus ulae</i>	0	-	2	39.0	0	-
<i>Taenianotus triacanthus</i>	1	45.0	0	-	0	-
<i>Antigonia eos</i>	1	45.0	0	-	0	-

Table 3.--Continued

Species	Depth zone					
	Deep			Mid		Shallow
	N	R	N	N	R	N
<i>Amanses (Cantherines) sp.</i>	0	-	1	52.0	0	-
<i>Apterichtus flavicaudus</i>	0	-	0	-	0	-
<i>Sammarsiscus corallinus</i>	0	-	1	52.0	0	-
<i>Brotula multibarbata</i>	0	-	1	52.0	0	-
<i>Centropyge fisheri</i>	0	-	1	52.0	0	-
<i>Cheilinus bimaculatus</i>	0	-	0	-	0	-
<i>Congrina aequorea</i>	0	-	1	52.0	0	-
<i>Dendrochirus barberi</i>	1	45.0	0	-	0	-
<i>Diodon hystrix</i>	0	-	1	52.0	0	-
<i>Epigonus fragilis</i>	0	-	1	52.0	0	-
<i>Festucalex erythraeus</i>	1	45.0	0	-	0	-
<i>Foa brachygramma</i>	0	-	1	52.0	0	-
<i>Chaetodon fremblii</i>	1	45.0	0	-	0	-
<i>Gempylidae (unidentified sp.)</i>	0	-	1	52.0	0	-
<i>Cirrhilabrus jordani</i>	1	45.0	0	-	0	-
<i>Carcharhinus milberti</i>	0	-	0	-	1	12.0
<i>Neomerinthe rufescens</i>	0	-	1	52.0	0	-
<i>Ophichthidae (unidentified sp.)</i>	1	45.0	0	-	0	-
<i>Physiculus sp.</i>	1	45.0	0	-	0	-
<i>Cirrimuraena playfairii</i>	1	45.0	0	-	0	-
<i>Pseudojuloides cerasinus</i>	0	-	0	-	0	-
<i>Psilogobius mainlandi</i>	0	-	1	52.0	0	-
<i>Pseudanthias winniensis</i>	1	45.0	0	-	0	-
<i>Synodus amaranthus</i>	0	-	1	52.0	0	-
<i>Sargocentron xantherythrum</i>	0	-	1	52.0	0	-
<i>Pristipomoides sieboldii</i>	0	-	1	52.0	0	-
<i>Synodus usitatus</i>	0	-	0	-	1	12.0
<i>Gymnothorax flavomarginatus</i>	0	-	0	-	0	-
<i>Gymnothorax mucifer</i>	0	-	0	-	0	-



BODY, WINGS, DOGEARS, AND JIBS ARE 18-THREAD, 2 1/2" STRETCH COTTON WEBBING.
TAIL IS 42-THREAD, 2 1/2" STRETCH COTTON WEBBING.

Figure 1.--A 74-ft (22.6-m) balloon trawl used on the merchant vessel Oregon (from fig. 10, U.S. Fish and Wildlife Service 1951).

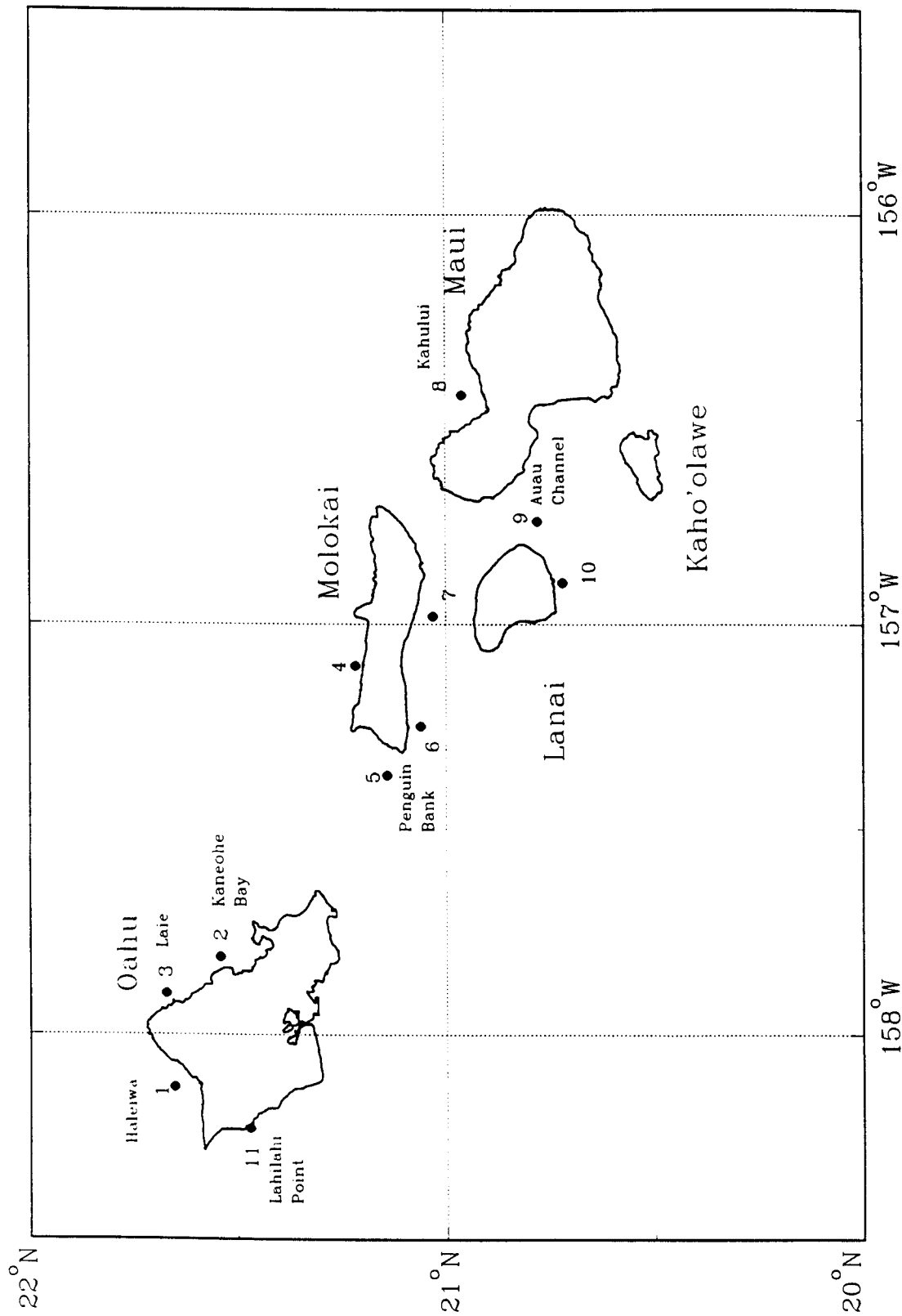


Figure 2.--Regions trawled by the Townsend Cromwell during cruise TC-90-10. See Table 1 for latitude and longitude positions for each region. (Latitude and longitude coordinates for this map are from the Hawaiian Island Mapping Program.)

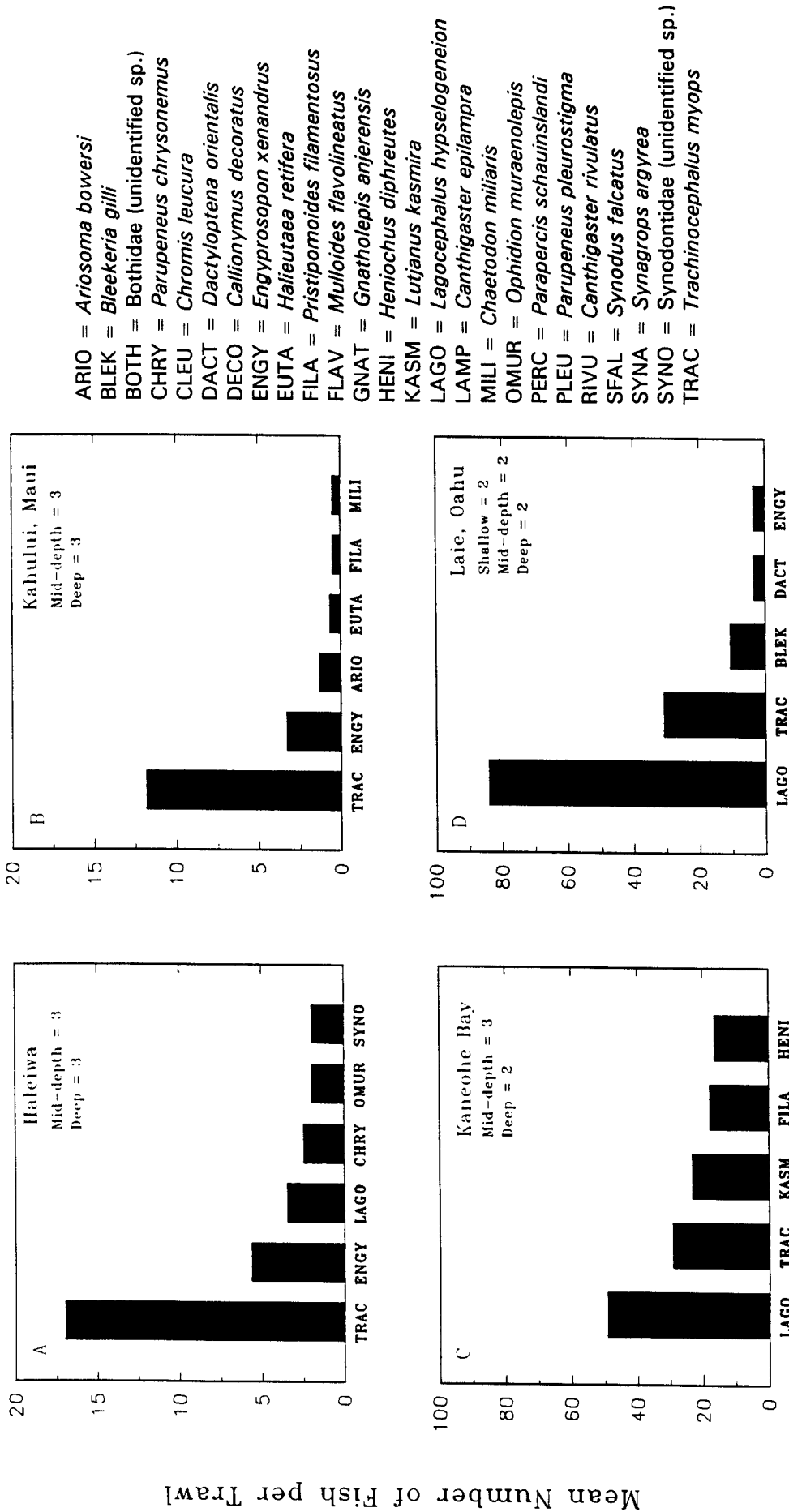


Figure 3.--(A-H). Mean number of fish per trawl for top-ranked species in eight regions. Number of trawls per depth are listed for each area.

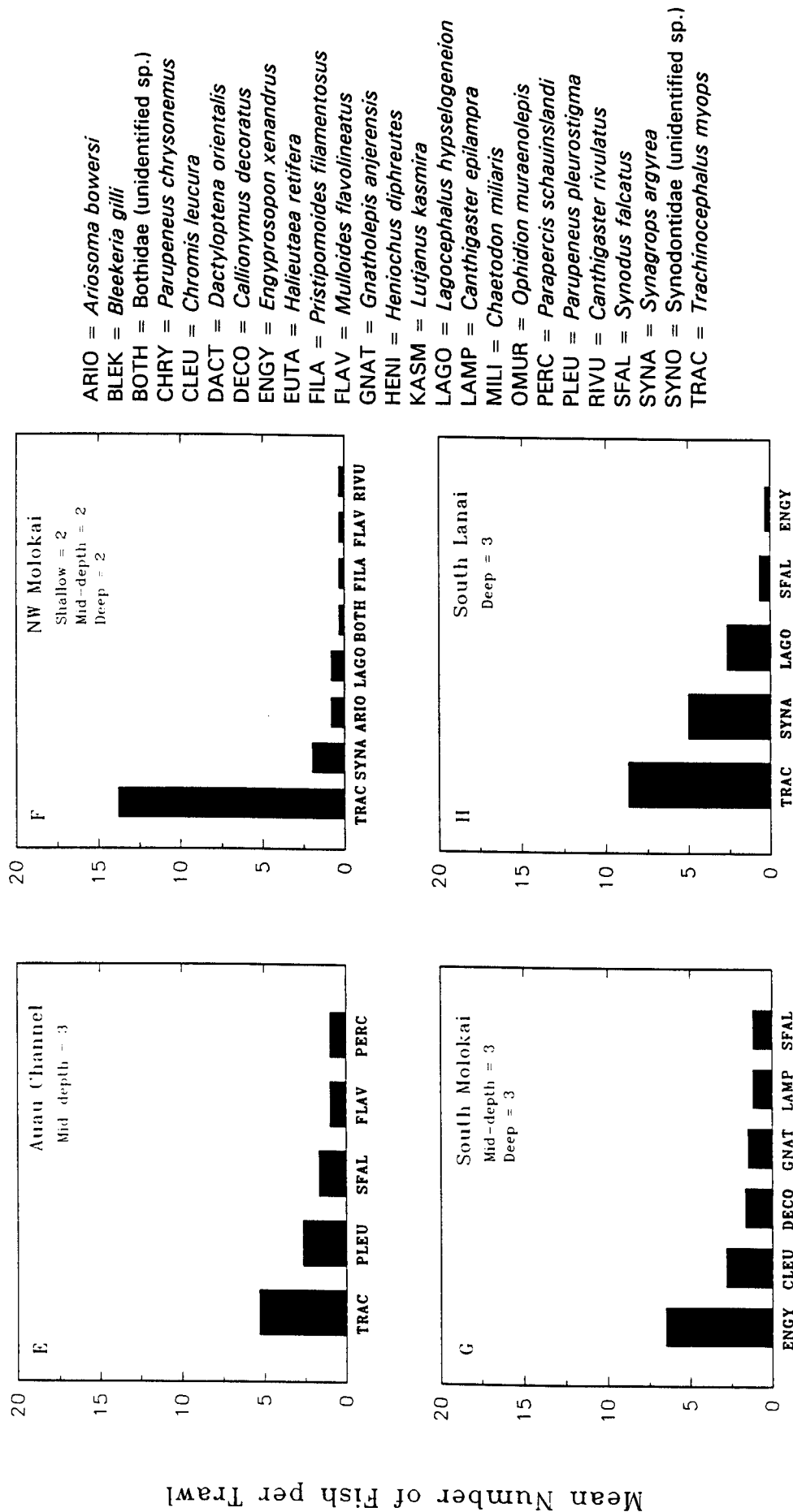


Figure 3.---Continued.

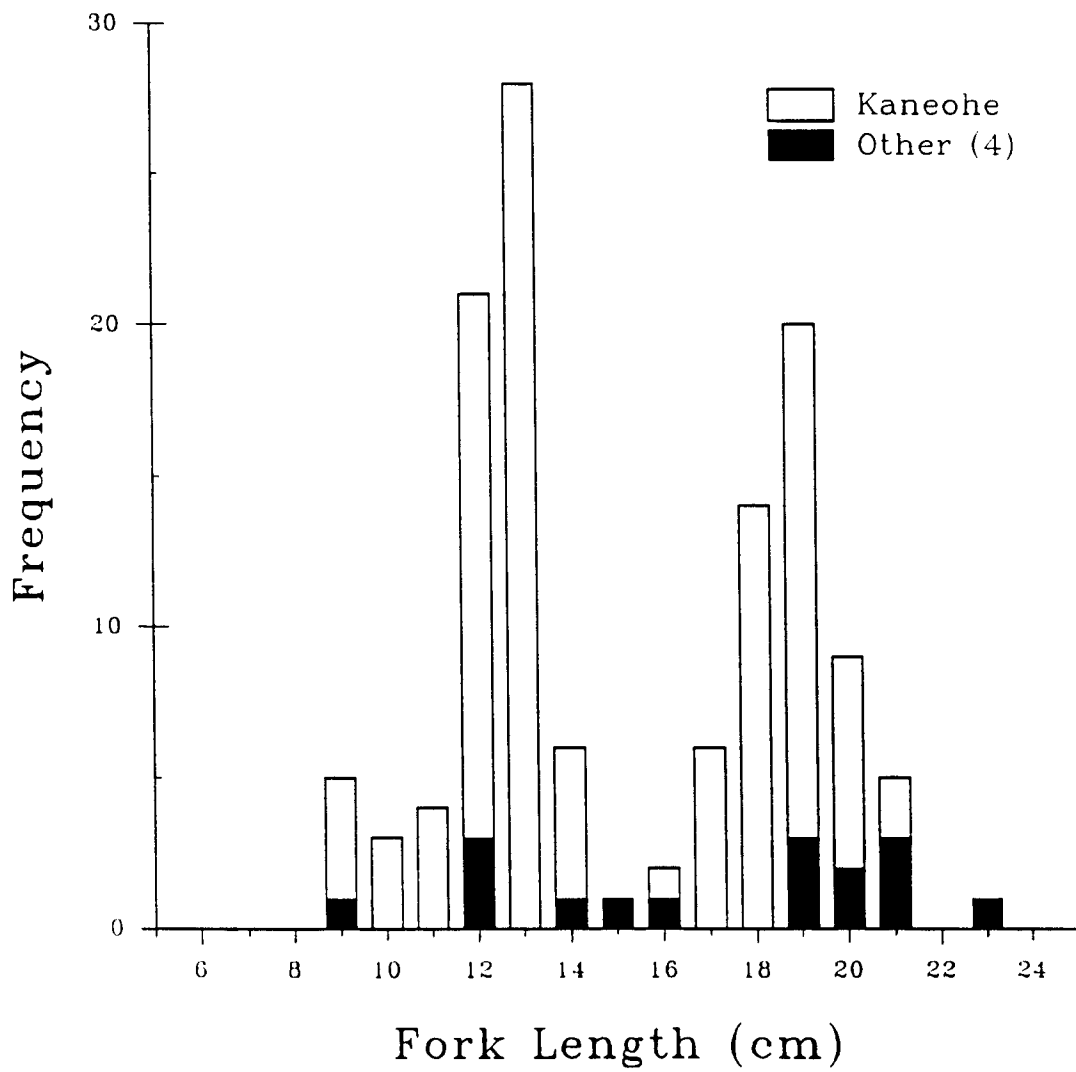


Figure 4.--Length-frequency distribution for opakapaka, *Pristipomoides filamentosus*, caught at Kaneohe Bay and four other regions. Fork length was rounded to the nearest centimeter.

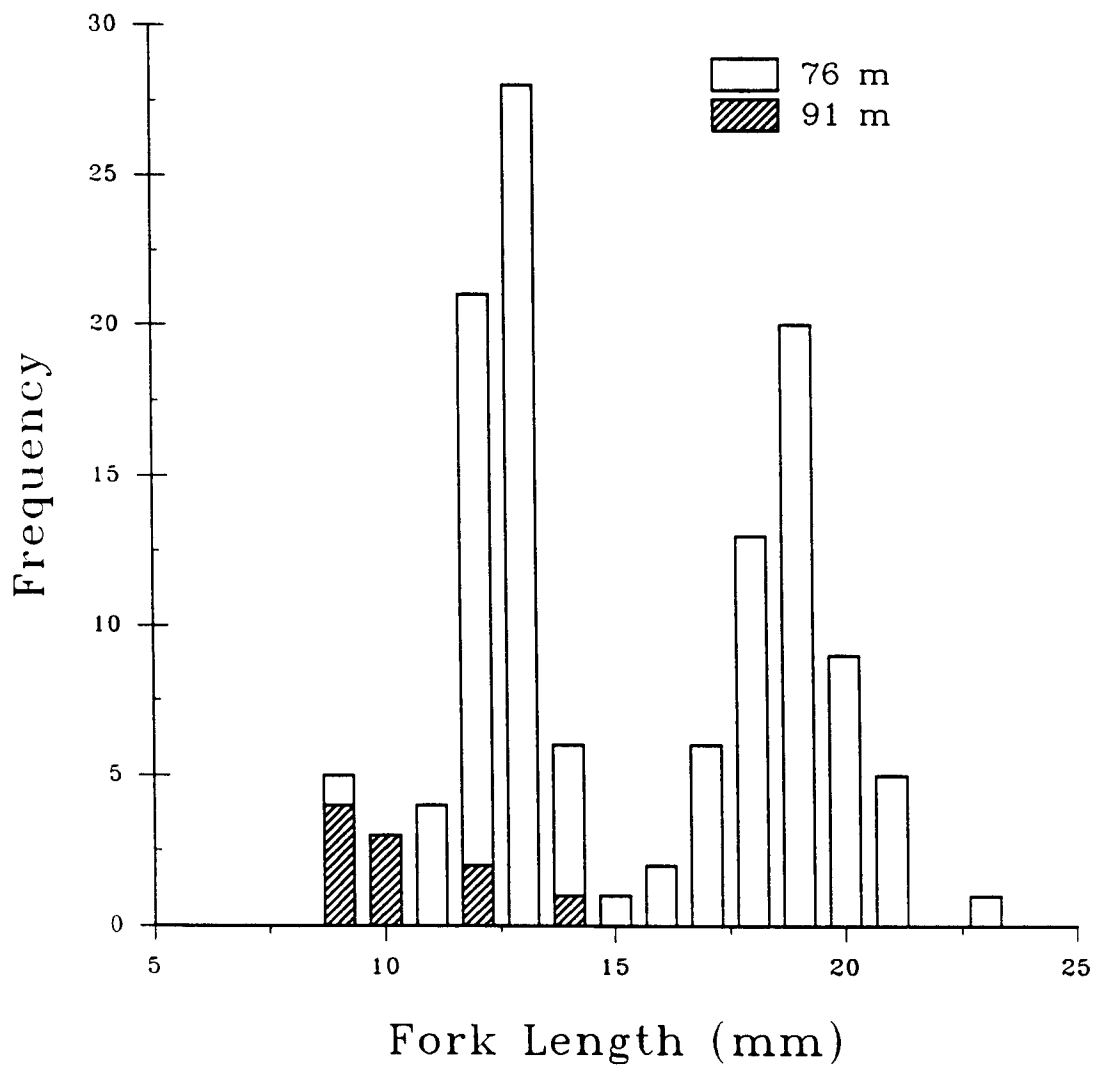


Figure 5.--Length-frequency distribution for opakapaka, *Pristipomoides filamentosus*, by depth of capture (with regions combined).

Appendix A.--Dates, depths, and positions of the 80 bottom
trawling stations during *Townsend Cromwell* cruise
90-10 in the main Hawaiian Islands.

Date	Station No.	Depth (m)		Midpoint	
		Range	Mean	Latitude (N)	Longitude (W)
11/29	13 ^a	84-91	88	21°38.4'	158°07.2'
11/29	14 ^a	- -	--	21°41.0'	158°05.0'
11/29	15	77-93	90	21°41.4'	158°05.0'
11/29	16	77-97	90	21°40.2'	158°06.0'
11/30	20	62-71	68	21°38.9'	158°06.8'
11/30	21	68-80	75	21°36.6'	158°09.0'
11/30	22	71-82	77	21°36.4'	158°11.7'
11/30	23	79-84	90	21°39.8'	158°06.2'
11/30	45	71-93	80	21°32.4'	157°48.1'
11/30	46	79-91	88	21°33.8'	157°48.0'
11/30	50	71-79	77	21°33.0'	157°47.8'
12/01	51 ^a	60-66	64	21°30.8'	157°47.8'
12/01	52 ^a	80-181+	--	21°31.2'	157°47.6'
12/01	56	73-77	75	21°33.8'	157°49.1'
12/01	57	84-91	88	21°33.9'	157°48.8'
12/01	79	70-77	73	21°41.3'	157°54.3'
12/01	80	73-77	75	21°39.8'	157°53.8'
12/02	84	77-88	84	21°40.7'	157°53.6'
12/02	85	86-95	88	21°39.8'	157°53.4'
12/02	101 ^a	51-62	57	21°39.6'	157°54.0'
12/02	102	51-59	55	21°41.0'	157°54.6'
12/02	103	53-59	57	21°40.6'	157°54.7'
12/02	104 ^a	49-64	60	21°30.0'	157°46.8'
12/03	122	57-64	60	21°12.0'	157°04.8'
12/03	123	84-91	88	21°11.8'	157°04.8'
12/03	127	55-60	57	21°12.2'	157°04.6'
12/03	128	86-91	90	21°12.2'	157°04.0'
12/03	129	73-79	75	21°12.3'	157°04.7'
12/04	133	75-90	80	21°12.2'	157°03.7'
12/04	150 ^a	88-97	91	21°09.3'	157°21.2'
12/04	151	86-91	88	21°09.2'	157°21.6'
12/04	155	53-59	55	21°08.0'	157°20.5'
12/04	156	53-60	59	21°08.3'	157°20.6'
12/05	160	68-82	80	21°09.2'	157°20.5'
12/05	161	62-77	75	21°07.4'	157°23.3'
12/05	172	66-75	70	21°02.9'	157°16.3'
12/05	173	82-101	91	21°03.6'	157°13.1'
12/05	177	84-97	88	21°03.2'	157°14.4'
12/05	178	66-77	73	21°02.9'	157°17.3'
12/06	182	60-82	75	21°04.1'	157°12.5'
12/06	183	53-86	71	21°04.1'	157°14.6'
12/06	203	70-84	79	21°02.6'	156°59.6'

Appendix A.--Continued.

Date	Station No.	Depth (m)		Midpoint	
		Range	Mean	Latitude (N)	Longitude (W)
12/06	204	70-79	75	21°02.8'	156°59.9'
12/06	208	60-77	70	21°01.8'	156°58.7'
12/06	209	82-90	86	21°02.0'	156°59.0'
12/07	213	79-97	90	21°01.1'	156°57.5'
12/07	214	66-99	82	21°00.5'	156°56.7'
12/07	235	84-88	86	20°58.3'	156°25.7'
12/07	236	91-95	93	20°58.1'	156°27.1'
12/07	240	70-79	77	20°57.2'	156°27.2'
12/07	241	70-75	73	20°57.2'	156°27.4'
12/08	245	71-79	77	20°57.5'	156°27.6'
12/08	246	84-90	88	20°58.1'	156°27.8'
12/09	267	62-77	66	20°46.8'	156°46.1'
12/09	268	68-80	71	20°47.5'	156°44.9'
12/09	269	68-93	73	20°47.5'	156°44.9'
12/10	270	93-99	95	20°43.1'	156°55.1'
12/10	271	82-90	88	20°43.2'	156°54.3'
12/10	272	86-95	90	20°43.1'	156°54.8'
12/10	273	55-59	55	21°03.8'	157°17.5'
12/10	274	49-57	53	21°03.9'	157°17.6'
12/10	275	64-66	64	21°03.1'	157°19.4'
12/10	276	84-91	88	21°02.6'	157°16.4'
12/10	277	84-91	90	21°02.6'	157°17.2'
12/10	278	70-77	75	21°03.1'	157°14.6'
12/10	279	68-77	71	21°03.1'	157°17.6'
12/10	280	57-60	59	21°03.9'	157°17.0'
12/10	281	55-59	57	21°03.8'	157°15.8'
12/11	282	73-82	77	21°27.5'	158°13.5'
12/11	283	86-110	99	21°27.4'	158°13.4'
12/11	284	70-88	77	21°28.0'	158°13.7'
12/11	285	70-86	73	21°28.4'	158°14.3'
12/12	286	84-90	88	21°38.7'	158°07.1'
12/12	287	86-93	90	21°39.1'	158°06.8'
12/12	288	71-75	73	21°36.9'	158°08.9'
12/12	289	70-73	71	21°38.3'	158°06.6'
12/12	290	44-60	53	21°38.9'	158°05.4'
12/12	291 ^a	49-64	62	21°39.9'	158°05.6'
12/12	292	49-64	60	21°38.7'	158°06.1'
12/12	293	53-64	60	21°38.9'	158°05.8'

^aNon-quantitative sample.

Appendix B.--Speed, duration, and distance of trawl for
the 80 bottom trawling stations sampled
during the *Townsend Cromwell* cruise 90-10
in the main Hawaiian Islands.

Station No.	Duration (min)	Speed (m/s)	Trawl distance (km)
13 ^a	31	1.32	2.46
14 ^a	39	1.32	3.09
15	32	1.32	2.53
16	32	1.32	2.53
20	31	1.32	2.46
21	30	1.32	2.38
22	32	1.32	2.53
23	32	1.32	2.53
45	31	1.32	2.46
46	32	1.32	2.53
50	31	1.32	2.46
51 ^a	13	1.32	1.03
52 ^a	30	1.32	2.38
56	31	1.32	2.46
57	30	1.32	2.38
79	31	1.32	2.46
80	28	1.32	2.22
84	31	1.32	2.46
85	32	1.32	2.53
101 ^a	29	2.10	3.65
102	33	1.53	3.03
103	31	1.68	3.12
104 ^a	29	1.58	2.75
122	19	2.10	2.39
123	19	2.10	2.39
127	19	1.63	1.86
128	20	2.10	2.52
129	20	2.21	2.65
133	19	2.21	2.52
150 ^a	19	2.21	2.52
151	18	2.37	2.56
155	19	1.84	2.10
156	19	2.00	2.28
160	20	2.10	2.52
161	18	2.63	2.84
172	20	2.21	2.65
173	21	2.26	2.85
177	20	2.37	2.84
178	19	2.47	2.82
182	19	2.52	2.87
183	19	2.10	2.39

Appendix B.--Continued.

Station No.	Duration (min)	Speed (m/s)	Trawl distance (km)
203	19	2.37	2.70
204	20	2.26	2.71
208	21	2.10	2.65
209	19	2.10	2.39
213	21	2.37	2.99
214	19	2.37	2.70
235	19	2.21	2.52
236	20	2.16	2.59
240	19	2.37	2.70
241	19	2.21	2.52
245	18	2.21	2.39
246	19	2.21	2.52
267	15	2.16	1.94
268	20	2.31	2.77
269	12	2.42	1.74
270	18	2.26	2.44
271	20	2.26	2.71
272	19	2.37	2.70
273	19	1.84	2.10
274	19	2.37	2.70
275	20	2.52	3.02
276	20	2.21	2.65
277	20	2.16	2.59
278	20	2.10	2.52
279	20	2.26	2.71
280	20	1.79	2.15
281	19	1.74	1.98
282	20	2.16	2.59
283	15	2.21	1.99
284	18	2.10	2.27
285	19	1.95	2.22
286	19	2.16	2.46
287	18	2.21	2.39
288	19	2.21	2.52
289	19	2.05	2.34
290	19	2.00	2.28
291 ^a	22	2.10	2.77
292	25	1.58	2.37
293	27	1.58	2.56

^aNon-quantitative sample

Appendix C.--Annotated bibliography of taxonomic keys used in identifying fishes caught during the *Townsend Cromwell* cruise TC-90-10--updated for current nomenclature (based on taxonomic review by Bruce Mundy, pers. commun.).

Allen, G. R.

1975. Damselfishes of the South Seas. TFH Publ, Neptune City, NJ, 240 p.

Re. *Chromis leucura* as synonym for *Chromis leucurus*.

Ben-Tuvia, A. and G. W. Kissil

1988. Fishes of the family Mullidae of the Red Sea, with a key to the species in the Red Sea and the eastern Mediterranean. Ichthyol. Bull. JLB Smith Inst Ichthyol. No. 52:1-16.

Re. *Mulloides flavolineatus* as synonym of *Mulloidichthys flavolineatus*; *Mulloides vanicolensis* as synonym of *Mulloidichthys auriflamma*.

Dawson, C. E.

1985. Indo-Pacific pipefishes (Red Sea and the Americas). Gulf Coast Re Lab, Ocean Springs, Miss 230 p.

Re. *Festucalex erythraeus* as synonym of *Ichthyocampus erythraeus*.

Eschmeyer, W. N. and J. E. Randall.

1975. The scorpaenid fishes of the Hawaiian Islands, including new species and new records (Pisces: Scorpaenidae). Procs. Calif. Acad. Sci. 40(11):265-334.

Re. Identification of *Dendrochirus barberi*, *Iracundus signifer*, *Neomerinthe rufescens*, *Scorpaena colorata*, *Scorpaenopsis altirostris*, *Scorpaenopsis brevifrons*, *Taenianotus triacanthus*.

Fricke, R.

1983. Revision of the Indo-Pacific genera and species of the dragonet family Callionymidae (Teleostei). Thesis Zoologicae 3:1-774.

Re. Identification of *Callionymus decoratus*.

Appendix C.--Continued.

Gon, O.

1985. Two new species of the deep-sea cardinalfish genus *Epigonus* (Perciformes, Apogonidae) from the Hawaiian Islands, with a key to the Hawaiian species. *Pac. Sci.* 39(2):221-229.

Re. Identification of *Epigonus fragilis*.

Gosline, W. A. and V. E. Brock.

1960. Handbook of Hawaiian Fishes. Univ. Hawaii Press, Honolulu, HI. 371 p.

Re. General fish identifications.

Hardy, G. S.

1983. The status of *Torquiniger florealis* (Bleeker) (Tetraodontiformes:Tetraodontidae) and some related species, including a new species from Hawaii. *Pac. Sci.* 37(1):65-74.

Re. *Torquiniger florealis* as synonym of *Lagocephalus hypselogeneion*.

Hensley, D. A. and A. Y. Suzumoto.

Unpubl. manuscr. Key to the Bothidae of Easter Island and the Hawaiian Islands.

Re. Identification of *Bothus thompsoni*, *B. pantherinus*, and *Engyprosopon xenandrus*.

Mayer, G. F.

1974. A review of the cardinalfish genus *Epigonus* (Perciformes, Apogonidae), with descriptions of two new species. *Bull. Mus. Comp. Zool.* 146(3):147-203.

Re. Family Epigonidae for *Epigonus fragilis*.

McCosker, J. E.

1979. The snake eels (Pisces, Ophichthyidae) of the Hawaiian Islands, with the description of two new species. *Procs. Calif. Acad. Sci.* 42(2):57-67.

Re. Identification of *Cirrimuraena playfairii* and *Apterichtus flavicaudus*.

Appendix C.--Continued.

Parin, N. V. and O. D. Borodulina.

1986. Preliminary review of the benthopelagic fish genus *Antigonia* Lowe (Zeiformes, Caproidae). Trans PP Shirshov Inst. Oceanol. 121:141-172. [In Russian, with Engl. Abstract].

Re. Identification of *Antigonia eos*.

Paulin, C. D.

1989. Review of the morid genera *Gadella*, *Physiculus*, and *Salilota* (Teleostei: Gadiformes) with descriptions of seven new species. New Zealand J. Zool. 16:93-133.

Re. *Physiculus* sp.

Pietsch, T. W. and D. B. Grobecker.

1987. Frogfishes of the world: systematics, zoogeography, and behavioral ecology. Stanford Univ. Press, Stanford, CA. 420 p.

Re. *Antennarius straitus* as synonym of *Phrynelox cunninghami*.

Randall, J. E.

1980. Revision of the fish genus *Plectranthias* (Serranidae; Anthiinae) with descriptions of 13 new species. Micronesica 16(1):101-187.

Re. Identification of *Plectranthias winniensis*.

Randall, J. E.

1985. Guide to Hawaiian Reef Fishes. Harrowood Books, Newton Square, PA, USA. 79 p.

Re. *Foa brachygramma* as synonym of *Apogon brachygrammus*.

Randall, J. E. and P. C. Heemstra.

1985. A review of the squirrelfishes of the subfamily Holocentrinae from the western Indian Ocean and Red Sea. Ichthyol. Bull. JLB Smith Inst. Ichthyol., No. 49:1-29.

Re. *Sargocentron xantherythrum* as synonym of *Adioryx xantherythrus*.

Appendix C.--Continued.

Randall, J. E. and S. N. Swerdloff.

1973. A review of the damselfish genus *Chromis* from the Hawaiian Islands, with descriptions of three new species. Pac. Sci. 267(4):327-349.

Re. Identification of *Synagrops argyrea*.

Schultz, L. P.

1940. Two new genera and three new species of cheilodipterid fishes, with notes on the other genera of the family. Procs. US Natl. Mus. 88(3085):403-423.

Re. Identification of *Synagrops argyrea*.

Smith, D. G., J. E. Bohlke and P. H. J. Castle.

1981. A revision of the nettastomatid eel genera *Nettastoma* and *Nettenchelys* (Pisces:Anguilliformes), with descriptions of six new species. Proc. Biol. Soc. Wash. 94(2):535-560.

Re. Unidentified eels of F. Nettastomatidae, cf *Saurenychelys* sp. .. also see Norman (no date, "A draft synopsis of the orders, families and genera of recent fishes and fish-like vertebrates", Brit. Mus. Nat. Hist.; for key to genera: and Smith, D. G. and P. H. J., 1982, Dana Rept., No. 90:1-44; for key to nettastomatid larvae.

Smith, M. M. and P. C. Heemstra.

1986. Smith's Sea Fishes. Springer-Verlag, NY. 1047 p.

Re. *Eurypegasmus papilio* as synonym of *Pegasus papilio*.

Waples, R. S. and J. E. Randall.

1988. A revision of the Hawaiian lizardfishes of the genus *Synodus*, with descriptions of four new species. Pac. Sci. 42(3/4):178-213.

Re. Identification of *Synodus amaranthus*, *S. falcatus*, *S. ulae*, and *S. usitatus*.

Wisner, R. L.

1976. The taxonomy and distribution of lanternfishes (family Myctophidae) of the eastern Pacific Ocean. US Govt. Print Off., Navy Ocean Research and Development Activity, Bay St. Louis, Mississippi. 229 p.

Re. Identification of *Benthosema fibulatum*.

Appendix D.--The fish taxa (both teleosts and elasmobranchs; alphabetized within family) trawled on the Townsend Cromwell cruise TC-90-10 in the main Hawaiian Islands, 1990. There are 89 taxa present in 47 families; 83 of the taxa were identified to genus and 77 to species.

Ammodytidae*Bleekeria gilli***Antennariidae***Antennarius striatus***Apogonidae**

Unidentified sp.
Apogon maculiferus
A. snyderi
Epigonus fragilis
Foa brachygramma
Synagrops argyrea

Bothidae

Unidentified sp.
Bothus pantherinus
B. thompsoni
Engyprosopon xenandrus

Brotulidae*Brotula multibarbata***Callionymidae***Callionymus decoratus***Canthigasteridae**

Canthigaster coronatus
C. epilampra
C. rivulatus

Caproidae*Antigonia eos***Carangidae***Decapterus macarellus***Carapidae***Carapis homei***Carcharhinidae***Carcharhinus milberti***Chaetodontidae**

Chaetodon fremblii
C. miliaris
Heniochus diphreutes

Cirrhitidae*Oxycirrhites typus***Congridae**

Ariosoma bowersi
Congrina aequorea

Dactylopteridae*Dactyloptena orientalis***Dasyatidae***Dasyatis* sp.**Diodontidae***Diodon hystrix***Fistulariidae***Fistularia petimba***Gempylidae**

Unidentified sp.

Appendix D.--Continued.

Gobiidae

Gnatholepis anjerensis
Psilogobius mainlandi

Holocentridae

Myripristis chryseres
Sargocentron
xantherythrum

Labridae

Cheilinus bimaculatus
Cirrillabrus jordani
Pseudojuloides cerasinus

Lutjanidae

Lutjanus kasmira
Pristipomoides
filamentosus
P. sieboldii

Monacanthidae

Amanses sp.

Moridae

Physiculus sp.

Mullidae

Mulloidies auriflamma
M. flavolineatus
Parupeneus chrysonemus
P. pleurostigma
Upeneus arge

Muraenidae

Gymnothorax
flavomarginatus
G. mucifer

Myctophidae

Benthosema fibulatum

Nettastiomatidae

Saurenhelys sp.

Nomeidae

Unidentified sp.

Ogcocephalidae

Halieutaea retifera

Ophichthyidae

Unidentified sp.
Apterichtus flavicaudus
Cirrimuraena playfairii

Ophidiidae

Ophidion muraenolepis

Ostraciontidae

Lactoria spp.

Parapercidae

Parapercis schauinslandi

Pegasidae

Eurypegasis papilio

Pleuronectidae

Sammariscus corallinus

Pomacanthidae

Centropyge fisheri
C. potteri

Appendix D.--Continued.

Pomacentridae

Chromis leucura
C. verater

Priacanthidae

Priacanthus alalaua

Scorpaenidae

Dendrochirus barberi
Iracundus signifer
Neomerinthe rufescens
Scorpaena colorata
Scorpaenopsis altirostris
S. brevifrons
Taenianotus triacanthus

Serranidae (Anthiinae)

Anthias thompsoni
Pseudanthias winniensis

Sphyraenidae

Sphyraena japonicus

Stomiidae

Astronesthes sp.

Syngnathidae

Festucalex erythraeus
Hippocampus kuda

Synodontidae

Unidentified sp.
Saurida nebulosa
Synodus amaranthus
S. falcatus
S. ulae
S. usitatus
Trachinocephalus myops

Tetraodontidae

Lagocephalus hypselogeneion

Appendix E.--Frequency and catch for all species caught during
the Townsend Cromwell cruise TC-90-10 in the main
Hawaiian Islands, 1990.

Species	Frequency (N trawls)	Total N caught (individuals)	Percent of total No.
<i>Benthoosema fibulatum</i>	40	1401	31.76
<i>Lagocephalus hypselogeneion</i>	25	851	19.29
<i>Trachinocephalus myops</i>	45	719	16.30
<i>Engyprosopon xenandrus</i>	31	228	5.17
<i>Lutjanus kasmira</i>	11	153	3.47
<i>Pristipomoides filamentosus</i>	12	123	2.79
<i>Synagrops argyrea</i>	14	122	2.77
<i>Heniochus diphreutes</i>	7	107	2.43
<i>Ariosoma bowersi</i>	25	64	1.45
<i>Bleekeria gilli</i>	2	64	1.45
<i>Dactyloptena orientalis</i>	14	54	1.22
<i>Parupeneus chrysonemus</i>	14	48	1.09
<i>Bothus thompsoni</i>	8	35	0.79
<i>Synodus falcatus</i>	15	29	0.66
<i>Lactoria</i> spp.	9	25	0.57
<i>Gnatholepis anjerensis</i>	8	21	0.48
<i>Priacanthus alalaua</i>	6	20	0.45
<i>Iracundus signifer</i>	6	19	0.43
<i>Canthigaster rivulatus</i>	10	19	0.43
Bothidae (unidentified sp.)	5	18	0.41
<i>Bothus pantherinus</i>	7	18	0.41
<i>Chromis leucura</i>	4	17	0.39
<i>Callionymus decoratus</i>	10	17	0.39
<i>Parapercis schauinsland</i>	8	15	0.34
<i>Mulloides auriflamma</i>	5	14	0.32
<i>Fistularia petimba</i>	5	14	0.32
<i>Ophidion muraenolepis</i>	4	14	0.32
<i>Parupeneus pleurostigma</i>	7	14	0.32
Synodontidae (unidentified sp.)	5	14	0.32
<i>Canthigaster epilampra</i>	6	12	0.27
<i>Scorpaena colorata</i>	8	12	0.27
<i>Mulloides flavolineatus</i>	7	11	0.25
<i>Chaetodon miliaris</i>	5	9	0.20
<i>Decapterus macarellus</i>	5	6	0.14
<i>Saurenhelys</i> sp.	5	6	0.14
<i>Chromis verater</i>	3	5	0.11
<i>Haliutaea retifera</i>	3	5	0.11
<i>Myripristis chryseres</i>	2	5	0.11
<i>Apogon maculiferus</i>	3	4	0.09
<i>Antennarius striatus</i>	4	4	0.09
<i>Canthigaster coronatus</i>	3	4	0.09
Apogonidae (unidentified sp.)	2	3	0.07
<i>Carapis homei</i>	3	3	0.07

Appendix E.--Continued.

Species	Frequency (N trawls)	Total N caught (individuals)	Percent of total No.
<i>Dasyatis</i> sp.	2	3	0.07
Nomeidae (unidentified sp.)	1	3	0.07
<i>Eurypegasus papilio</i>	2	3	0.07
<i>Scorpaenopsis altirostris</i>	3	3	0.07
<i>Scorpaenopsis brevifrons</i>	1	3	0.07
<i>Oxycirrhites typus</i>	2	3	0.07
<i>Anthias thompsoni</i>	2	2	0.05
<i>Upeneus arge</i>	1	2	0.05
<i>Apogon snyderi</i>	1	2	0.05
<i>Centropyge potteri</i>	1	2	0.05
<i>Hippocampus kuda</i>	2	2	0.05
<i>Sphyraena japonicus</i>	2	2	0.05
<i>Synodus ulae</i>	2	2	0.05
<i>Taenianotus triacanthus</i>	2	2	0.05
<i>Antigonia eos</i>	1	1	0.02
<i>Amanses</i> (Cantherines) sp.	1	1	0.02
<i>Apterichtus flavicaudus</i>	1	1	0.02
<i>Sammariscus corallinus</i>	1	1	0.02
<i>Astronesthes</i> sp.	1	1	0.02
<i>Brotula multibarbata</i>	1	1	0.02
<i>Centropyge fisheri</i>	1	1	0.02
<i>Cheilinus bimaculatus</i>	1	1	0.02
<i>Congrina aequorea</i>	1	1	0.02
<i>Dendrochirus barberi</i>	1	1	0.02
<i>Diodon hystrix</i>	1	1	0.02
<i>Epigonus fragilis</i>	1	1	0.02
<i>Festucalex erythraeus</i>	1	1	0.02
<i>Foa brachygramma</i>	1	1	0.02
<i>Chaetodon fremblii</i>	1	1	0.02
Gempylidae (unidentified sp.)	1	1	0.02
<i>Cirrhitilabrus jordani</i>	1	1	0.02
<i>Carcharhinus milberti</i>	1	1	0.02
<i>Neomerinthe rufescens</i>	1	1	0.02
Ophichthidae (unidentified sp.)	1	1	0.02
<i>Physiculus</i> sp.	1	1	0.02
<i>Cirrimuraena playfairii</i>	1	1	0.02
<i>Pseudojuloides cerasinus</i>	1	1	0.02
<i>Psilogobius mainlandi</i>	1	1	0.02
<i>Pseudanthias winniensis</i>	1	1	0.02
<i>Synodus amaranthus</i>	1	1	0.02
<i>Sargocentron xantherythrum</i>	1	1	0.02
<i>Pristipomoides sieboldii</i>	1	1	0.02
<i>Synodus usitatus</i>	1	1	0.02
<i>Gymnothorax flavomarginatus</i>	1	1	0.02
<i>Gymnothorax mucifer</i>	1	1	0.02

Appendix F.--Frequency and aggregate weight during the *Townsend Cromwell* cruise 90-10 in the main Hawaiian Islands, 1990, for each species caught.

Species	Frequency (No. trawls)	Aggregate weight	
		kg	Percent
<i>Dasyatis</i> sp.	2	95.00	37.46
<i>Lagocephalus hypselogeneion</i>	25	73.89	29.14
<i>Trachinocephalus myops</i>	45	32.66	12.88
<i>Lutjanus kasmira</i>	11	10.47	4.13
<i>Pristipomoides filamentosus</i>	12	8.72	3.44
<i>Carcharhinus milberti</i>	1	4.04	1.59
<i>Benthoosema fibulatum</i>	40	3.92	1.55
<i>Heniochus diphreutes</i>	7	3.03	1.19
<i>Ariosoma bowersi</i>	25	2.18	0.86
<i>Dactyloptena orientalis</i>	14	2.18	0.86
<i>Parupeneus chrysonemus</i>	14	1.56	0.62
<i>Mulloides auriflamma</i>	5	1.48	0.58
<i>Synagrops argyrea</i>	14	1.31	0.52
<i>Mulloides flavolineatus</i>	7	1.30	0.51
<i>Chromis verater</i>	3	1.27	0.50
<i>Bothus pantherinus</i>	7	0.91	0.36
<i>Diodon hystrix</i>	1	0.87	0.34
<i>Lactoria</i> spp.	9	0.82	0.32
<i>Gymnothorax flavomarginatus</i>	1	0.80	0.32
<i>Bleekeria gilli</i>	2	0.79	0.31
<i>Priacanthus alalaua</i>	6	0.70	0.28
<i>Engyprosopon xenandrus</i>	31	0.60	0.24
<i>Bothus thompsoni</i>	8	0.54	0.21
<i>Parupeneus pleurostigma</i>	7	0.50	0.20
<i>Canthigaster rivulatus</i>	10	0.49	0.19
<i>Chaetodon miliaris</i>	5	0.39	0.15
<i>Synodus falcatus</i>	15	0.36	0.14
<i>Decapterus macarellus</i>	5	0.35	0.14
<i>Upeneus arge</i>	1	0.27	0.11
<i>Fistularia petimba</i>	5	0.27	0.11
<i>Synodus ulae</i>	2	0.16	0.06
<i>Sphyræna japonicus</i>	2	0.15	0.06
Synodontidae (unidentified sp.)	5	0.13	0.05
<i>Anthias thompsoni</i>	2	0.12	0.05
<i>Iracundus signifer</i>	6	0.12	0.05
<i>Ophidion muraenolepis</i>	4	0.12	0.05
Nomeidae (unidentified sp.)	1	0.10	0.04
<i>Gymnothorax mucifer</i>	1	0.10	0.04
Bothidae (unidentified sp.)	5	0.09	0.04
<i>Brotula multibarbata</i>	1	0.09	0.04
<i>Chromis leucura</i>	4	0.09	0.04
<i>Callionymus decoratus</i>	10	0.08	0.03
<i>Haliutæa retifera</i>	3	0.08	0.03
<i>Canthigaster coronatus</i>	3	0.07	0.03

Appendix F.--Continued.

Species	Frequency (No. trawls)	Aggregate weight	
		kg	Percent
<i>Canthigaster epilampra</i>	6	0.07	0.03
<i>Chaetodon fremblii</i>	1	0.06	0.02
<i>Antennarius striatus</i>	4	0.05	0.02
<i>Pristipomoides sieboldii</i>	1	0.05	0.02
<i>Parapercis schauinslandi</i>	8	0.03	0.01
<i>Sargocentron xantherythrum</i>	1	0.03	0.01
<i>Apogon maculiferus</i>	3	0.02	0.01
<i>Apogon snyderi</i>	1	0.02	0.01
<i>Centropyge potteri</i>	1	0.02	0.01
<i>Sammariscus corallinus</i>	1	0.01	0.00
<i>Congrina aequorea</i>	1	0.01	0.00
<i>Myripristis chryseres</i>	2	0.01	0.00
<i>Eurypegasmus papilio</i>	2	0.01	0.00
<i>Scorpaenopsis altirostris</i>	3	0.01	0.00
<i>Scorpaena colorata</i>	8	0.01	0.00
<i>Antigonia eos</i>	1	<0.01	0.00
<i>Amanses (Cantherines) sp.</i>	1	<0.01	0.00
<i>Apogonidae (unidentified sp.)</i>	2	<0.01	0.00
<i>Apterichtus flavicaudus</i>	1	<0.01	0.00
<i>Astronesthes sp.</i>	1	<0.01	0.00
<i>Centropyge fisheri</i>	1	<0.01	0.00
<i>Cheilinus bimaculatus</i>	1	<0.01	0.00
<i>Carapis homei</i>	3	<0.01	0.00
<i>Dendrochirus barberi</i>	1	<0.01	0.00
<i>Epigonus fragilis</i>	1	<0.01	0.00
<i>Festucalex erythraeus</i>	1	<0.01	0.00
<i>Foa brachygramma</i>	1	<0.01	0.00
<i>Gempylidae (unidentified sp.)</i>	1	<0.01	0.00
<i>Gnatholepis anjerensis</i>	8	<0.01	0.00
<i>Hippocampus kuda</i>	2	<0.01	0.00
<i>Cirrhilabrus jordani</i>	1	<0.01	0.00
<i>Saurenhelys sp.</i>	5	<0.01	0.00
<i>Neomerinthe rufescens</i>	1	<0.01	0.00
<i>Ophichthidae (unidentified sp.)</i>	1	<0.01	0.00
<i>Physiculus sp.</i>	1	<0.01	0.00
<i>Cirrimuraena playfairii</i>	1	<0.01	0.00
<i>Pseudojuloides cerasinus</i>	1	<0.01	0.00
<i>Psilogobius mainlandi</i>	1	<0.01	0.00
<i>Pseudanthias winniensis</i>	1	<0.01	0.00
<i>Synodus amaranthus</i>	1	<0.01	0.00
<i>Scorpaenopsis brevifrons</i>	1	<0.01	0.00
<i>Synodus usitatus</i>	1	<0.01	0.00
<i>Taenianotus triacanthus</i>	2	<0.01	0.00
<i>Oxycirrhites typus</i>	2	<0.01	0.00